UK Government

iDeeksha

BUREAU OF ENERGY EFFICIENCY
Government of India, Ministry of Power

GOVERNMENT OF INDIA
MINISTRY OF POWER

ASPIRE PROGRAMME

Accelerating Smart Power & Renewable Energy in India

Business Trip to the United Kingdom (UK)

Industrial Energy Efficiency and Decarbonisation

20th - 23rd May 2024

Summary Report

CONTENTS

ABBREVIATIONS AND ACRONYMS

AFR	Alternative Fuels and Raw Material
ASPIRE	Accelerating Smart Power and Renewable Energy in India
B2B	Business to Business
BEE	Bureau of Energy Efficiency
BESS	Battery Energy Storage System
BII	British International Investment
CAP	Climate Action Programme
CCTS	Carbon Credit Trading Scheme
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilisation
CCUS	Carbon Capture, Utilisation and Storage
CEO	Chief Executive Officer
CFD	Computational Fluid Dynamics
CH2i	Cranfield Hydrogen Integration Incubator
CHP	Combined Heat and Power
CII	Confederation of Indian Industry
CNG	Compressed Natural Gas
CMA	Cement Manufacturers' Association
CO_2	Carbon Dioxide
DESNZ	Department for Energy Security and Net Zero
DSIT	Department for Science, Innovation and Technology
EESL	Energy Efficiency Services Limited
EHS	Environment, Health, and Safety
EPAL	Energy Pro Assets Limited
EPC	Engineering, Procurement and Construction
ESC	Energy Systems Catapult
ESCO	Energy Service Company
ESP	Electrostatic Precipitator
FCDO	Foreign, Commonwealth and Development Office
FICCI	Federation of Indian Chambers of Commerce and Industry
FEED	Front-End Engineering Design
FI	Foundation Industries
GHG	Greenhouse Gases
GoI	Government of India

Hrs	Hours
IEED	Industrial Energy Efficiency and Decarbonisation
IDEEKSHA	Industrial Decarbonisation and Energy Efficiency Knowledge Sharing Platform
IPP	Independent Power Producer
JLR	Jaguar Land Rover
kWe	Kilowatt Electric
MACE	Mechanically Assisted Chemical Exfoliation
MEA	Monoethanolamine
MHIPL	My Home Industries Private Limited
MI-CFD	Mineral Interactive CFD
MoP	Ministry of Power
MTPA	Million Tonnes Per Annum
MW	Megawatt
NDC	Nationally Determined Contributions
NZIP	Net Zero Innovation Portfolio
PAT	Perform, Achieve and Trade
RDF	Refuse Derived Fuel
RE	Renewable Energy
RE RTC	Renewable Energy Round the Clock
SAETF	SUSI Asia Energy Transition Fund
SBTi	Science Based Targets initiative
SMR	Small Modular Reactors
SMSC	Sustainable Manufacturing Systems Centre
SPL	Spent Pot Lining
TPH	Tonnes Per Hour
TSR	Thermal Substitution Rate
TransFIRe	Transforming Foundation Industries Research and Innovation Hub
UKRI	UK Research and Innovation
ZnO	Zinc Oxide

1 BACKGROUND AND OBJECTIVES OF THE BUSINESS TRIP

The Government of India (GoI) has announced its ambition to reduce emissions by 45 percent by 2030 and achieve net-zero emissions by 2070. This requires smart, agile and flexible systems and enhanced energy efficiency and decarbonisation measures across sectors. In this regard, various initiatives have been undertaken by the Bureau of Energy Efficiency (BEE) to drive energy efficiency and wider adoption of decarbonisation technologies among energy intensive industries.

Enhancing energy efficiency and decarbonisation have always been key focus areas for the Foreign, Commonwealth and Development Office (FCDO), and it has partnered with the Ministry of Power (MoP) and BEE on multiple initiatives to this effect in the past. To date, significant developments in energy efficiency and decarbonisation have occurred in the UK. Given these, BEE highlighted that a business trip to the UK, undertaken by delegates from the energy intensive Indian Aluminium and cement industries, would enable a transfer of knowledge to accelerate the energy transition journey in India.

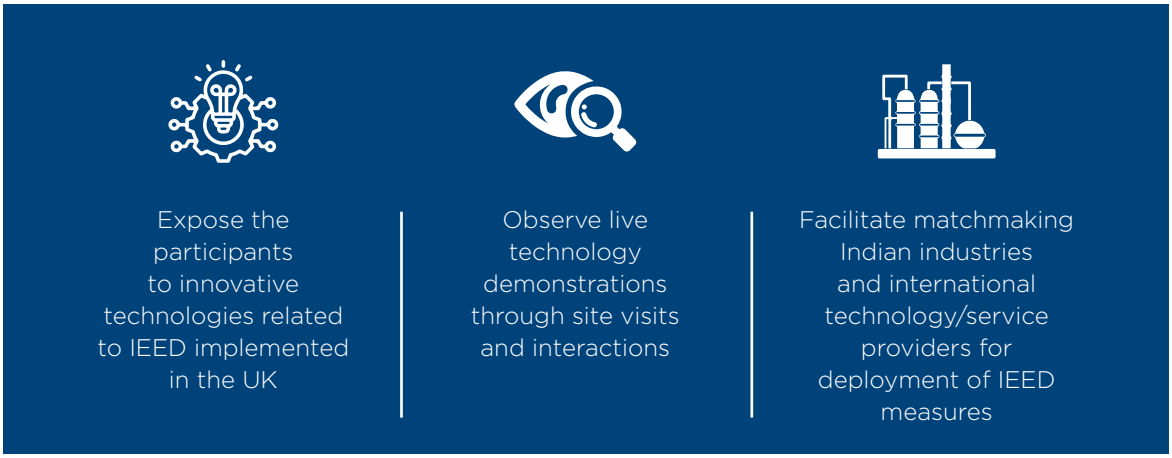
The trip was planned from 20th to 23rd May 2024 and included participants from the MoP, BEE, FCDO and ASPIRE team. This trip was also organised as part of the development of the "Industrial Decarbonisation and Energy Efficiency Knowledge Sharing (IDEEKSHA)" platform[1], which has been developed by the ASPIRE programme and BEE. The ASPIRE is a bilateral programme being implemented by the FCDO, UK Government in association with the Ministry of Power and the Ministry of New and Renewable Energy, Government of India.

The detailed agenda of the trip is provided in Annexure - 1 and the composition of the delegation is provided in Annexure - 2.

Objectives of the trip

The primary purpose of this trip was to promote knowledge sharing and foster technology partnership between UK and Indian industries operating in the Industrial Energy Efficiency and Decarbonisation (IEED) space. The trip also served to provide practical exposure to innovate IEED technologies for industry, MoP and BEE officials through direct interactions with entities in the UK. The specific objectives of this trip were to:

1 IDEEKSHA platform serves as a one-stop shop for all IEED needs of Indian energy intensive sectors. It hosts database of national and international technologies/service providers working in the areas of IEED. The platform also facilitates exchange of knowledge and information to enhance peer-to-peer learning, enable access to best practices across sectors, energy management tools, technologies and create knowledge repositories. This platform was launched by the Hon'ble Cabinet Minister for Power and New and Renewable Energy, Government of India on 1st March 2023, in New Delhi. Platform can be accessed from the following link – https://www.ideeksha.in



In line with the above objectives, the following activities were delivered:

- **Roundtable discussions** to foster UK-India partnerships, to promote sharing of IEED measures and to share insights between UK and India based organisations on deployment of IEED technologies.
- **Field visits** to select industrial units and centres of excellence to understand performance of low carbon technologies in operational conditions, the investment required to develop and operate said technologies and any other parameters relevant for success and deployment in India.
- **B2B meetings** between UK technology providers, industry associations and research institutes to help the Indian industries understand the leading practices being followed in UK.

Highlights

This report presents the detailed summary of the discussions and interactions carried out during the business trip.

2 DAY 1 ROUNDTABLE DISCUSSION

A roundtable discussion to facilitate dialogue between Indian and international entities was organised on the 20th May 2024 at KPMG UK's office in Canary Wharf, London. The roundtable discussion witnessed participation from 10 Indian delegates and 7 UK organisations/ research institutes. The UK delegates included officials from UK Research and Innovation (UKRI), Mineral Products Association (MPA), Coomtech Clean Technologies, CINAR, British International Investment (BII), Edina and Imperial College London.

The agenda for the roundtable discussion is provided below:

S. No.	Name of Session	Time
Inaugural Session		
1.	Address by KPMG UK (Mr. Tom Williams, Director, KPMG)	13:00 - 13:10 hours
2.	Welcome Address and Introduction to ASPIRE programme (Ms. Archana Chauhan, Head, Energy Sector Reform, British High Commission)	13:10 - 13:20 hours
3.	Context setting presentation (Mr. Vikas Gaba, Programme Director, ASPIRE programme; Partner & National Head, Power & Utilities, KPMG)	13:20 - 13:30 hours
4.	Keynote address by Ministry of Power, Government of India (Mr. Dhiraj Kumar Srivastava, Chief Engineer, Ministry of Power)	13:30 - 13:40 hours
Introduction of Indian industry delegation		
5.	Presentation by Indian companies	13:40 - 14:05 hours
Energy efficiency and decarbonisation initiatives in the UK		
6.	Presentation by UK Research and Innovation (UKRI) (Bruce Adderley, Challenge Director, TFI[2])	14:05 - 14:25 hours
7.	Presentation by Mineral Product Association (MPA) (Diana Casey, Executive Director)	14:25 - 14:45 hours
8.	Presentation by Coomtech Clean Technologies (Miri Zlatnar, Sales Director)	14:45 - 15:05 hours
Tea Break		**15:05 - 15:20 hours**
9.	Presentation by CINAR (Tahir Abbas, Director)	15:20 - 15:40 hours
10.	Presentation by British International Investment (Sami Khan, Director)	15:40 - 16:00 hours

2 'Transforming Foundation Industries' (TFI) challenge is part of the 'clean growth' theme under UKRI Challenge Fund.

S. No.	Name of Session	Time
11.	Presentation by Edina (Adam Bloom, CEO; Hugh Richmond, Strategic Advisor)	16:00 - 16:20 hours
12.	Presentation by Imperial College, London (Michel-Alexandre, Associate Professor)	16:20 - 16:40 hours
13.	Closing Remarks	16:40 - 17:00 hours
14.	Informal Interaction	17:00 - 17: 30 hours

2.1. Inaugural session

The inaugural session was moderated by Tom Williams, Director, KPMG UK. It started with a welcome address by Archana Chauhan, Head - Energy Sector Reforms, British High Commission to India. She mentioned that significant investments are required in the renewable energy and energy efficiency space to achieve India's commitment of net-zero emissions by 2070 but highlighted the need to balance economic growth and environmental impact. She also outlined the scope of the ASPIRE programme and IDEEKSHA platform.

Vikas Gaba, Programme Director of ASPIRE Programme, then delivered a context setting presentation. He provided an overview of the cement and aluminium sectors in India, which contribute to 8% and 6% of global output of both materials respectively. He also highlighted the decarbonisation levers which can be adopted across these sectors, including integration of Renewable Energy Round the Clock (RE RTC) power, enhanced usage of alternate fuels like green hydrogen, carbon capture utilisation and storage, adoption of measures to promote circular economy and waste heat recovery systems.

This was followed by a special address from Dhiraj Kumar Srivastava, Chief Engineer at MoP who stated that the Government of India is committed to meet its near-term Nationally Determined

Contributions (NDC) goals and net zero commitments by 2070. He explained key initiatives undertaken by GoI such as the Perform, Achieve and Trade (PAT) scheme; Street Light National Programme; Standards and Labelling Programme and Carbon Credits Trading Scheme (CCTS) undertaken to achieve these targets. He also emphasised the importance of technological innovation and the need for trillions of dollars in funding to strengthen the decarbonisation efforts of the Indian industries.

Key takeaways

- There is a need to balance economic growth and environmental impact in the pursuit of net zero economy by 2070.
- Significant investments will be required in the renewable energy and energy efficiency space to meet India's ambition of achieving Net-Zero economy by 2070.
- A combination of innovative low carbon technologies need to be adopted for the effective decarbonisation of aluminium and cement sectors.

2.2 Introduction of Indian industry delegation

Session 2 included introductory presentations by Indian delegates from the cement and aluminium industries. The delegates provided an overview of their respective companies, highlighted the decarbonisation initiatives currently underway and outlined their expectations from the business trip.

1. **Sagar Cements Limited**

   Anji Reddy, Senior Vice President at Sagar Cements Limited stated that the company has 6 plants with an installed capacity of 10.85 Million Tonnes Per Annum (MTPA). He mentioned that Sagar Cements has implemented various decarbonisation measures like: (a) installation of a six stage pre-heater system to reduce specific thermal consumption, (b) utilisation of a pre-grinding roller press to reduce specific electricity consumption, (c) use of Computational Fluid Dynamics (CFD) techniques for process optimisation. He also highlighted that the company intends to increase the use of alternative fuels for pyro-process and enhance the use of de-carbonated raw materials in its cement plants.

2. **My Home Industries Private Limited (MHIPL)**

   Kapilavai Narayana Rao, Corporate Head (EHS and Sustainability) at MHIPL specified that MHIPL manufactures cement under the brand name of 'Maha Cement'. He explained several of MHIPL's decarbonisation initiatives, such as the installation of waste heat recovery system in its cement plants and usage of alternative solid and liquid fuels in its cement kiln to reduce fossil fuel consumption. To further boost decarbonisation efforts, MHIPL is looking for technology and business partners to implement technologies like Carbon Capture, Utilisation and Storage (CCUS), electrification of cement manufacturing process and production of bio CNG.

3. **Shree Cement Limited**

   Man Mohan Rathi, Joint President (Power) at Shree Cement Limited informed that Shree Cement Limited is the 3rd largest cement company in India with installed capacity of 56.4 MTPA and power generation capacity of 983 MW. He underlined several decarbonisation

initiatives, which include: (a) Science Based Targets initiative (SBTi) based Greenhouse Gases (GHG) emissions reduction goals, (b) A target of 100% of electricity generation from renewable sources by 2050, (c) and the production of low carbon/blended cement. He also explained that Shree Cement is keen to explore usage of crop residues & municipal solid waste as fuels in cement kilns to reduce emissions.

4. Prism Johnson Limited

Manish Singh, President & Plant Head plant and Om Prakash, Vice President at Prism Johnson Limited Satna stated that Prism Johnson Limited is one of the largest integrated building materials companies in India. Representatives from Prism Johnson Limited mentioned the cement plant has an installed capacity of 5.6 MTPA. They added that the company has achieved a Thermal Substitution Rate (TSR) of 15% and aims to increase this to 25% by mid-2025. It was further highlighted that the company is exploring measures to: (a) reduce clinker utilisation factor, (b) utilise hydrogen as fuel in cement kilns, (c) replace limestone in cement production, the biggest carbon emitter in the entire value chain, etc. to reduce its emissions.

5. UltraTech Cement

Rajesh Sankar, President of UltraTech Cement, highlighted that Rawan Cement Works is the largest unit of UltraTech Cement in the eastern cluster of India. It has an installed capacity of over 6.5 MTPA for clinker production and 3.3 MTPA for cement production. He stated that UltraTech has deployed various decarbonisation measures, such as 15% Alternative Fuels and Raw Material (AFR) utilisation in the fuel mix and the installation of state-of-the-art pollution control equipment like Electrostatic Precipitators (ESP). He also mentioned that the company intends to increase circularity and the share of Renewable Energy (RE) in its energy mix to decarbonise its operations.

6. Vedanta Aluminium

Sachin Gupta, Deputy Business Head (Power and Supply) at Vedanta Aluminium, shared that Vedanta Aluminium is the largest producer of aluminium in India, producing more than half of India's aluminium in FY 2024 (2.37 million tonnes). He added that the company has set targets to: (a) achieve Net Zero emissions by 2050, (b) meet 30% of power requirements through RE by 2030, and (c) achieve a 28% reduction in GHG emissions by 2030. He further informed that the dissemination of best practices related to energy-efficient technologies like inert anodes and digitalisation efforts implemented in the UK will be critical to forging partnerships with UK organisations and technology providers.

7. Cement Manufacturers' Association (CMA)

Shubho Chakravarty, Assistant Manager at CMA, informed that CMA is the apex body of large cement manufacturers, representing about 75% of the installed capacity of India's cement sector. He specified that CMA is engaged in providing legal opinions, building global partnerships, and offering a networking platform for cement companies in India. He further said that CMA has aligned its goals with the Government of India's aspiration to achieve Net Zero by 2070.

8. Hindalco Industries Belagavi

Subhas Nesargi, Head of the Electrical & Instrumentation Department at Hindalco Industries Limited, stated that Hindalco is the world's largest aluminium rolling company. He informed that the decarbonisation measures implemented by the Belagavi unit of Hindalco include the installation of a 21 MW wind plant and the deployment of a 4 MW biomass-based cogeneration plant with 33 TPH capacity. He reiterated the company's commitment to achieving Net Zero by 2050 and added that the company is open to implementing technologies and measures like the adoption of electrode boilers, the installation of biogas plants, and battery energy storage plants to reduce its carbon footprint.

9. Dalmia Cement (Bharat) Limited

Vinay Kapil, Executive Director (Power) at Dalmia Cement (Bharat) Limited, stated that Dalmia Cement has a manufacturing capacity of 44.6 MTPA and operates 15 cement plants and grinding units across 10 Indian states. He mentioned that the company has received numerous accolades at national and international levels, such as the FICCI Indian Circular Economy Awards 2022, the 24th CII National Energy Awards 2023, and the CII CAP 2.0° Award for Pioneering Climate Action Initiatives in India, for its implementation of energy efficiency and decarbonisation initiatives. He also mentioned that Dalmia Cement intends to become carbon negative by 2040 through: (a) the use of sustainable fuels like biomass and RDF, (b) an increase in energy productivity, and (c) the adoption of advanced technologies like heat electrification, solar calcination, and CCU.

2.3 Energy efficiency and decarbonisation initiatives in the UK

This session focused on sharing experiences and details of services provided by various UK companies. Overall, seven companies presented on technologies and services available to the Indian delegates. The session was moderated by Cathy Chen, Associate Director at KPMG UK.

1. UK Research and Innovation (UKRI) - Bruce Adderley, Challenge Director

a. Bruce informed that UK Research and Innovation (UKRI) is a government body funded by the Department for Science, Innovation and Technology (DSIT), Government of the UK, which invests in research and innovation across nine councils to drive economic growth in the UK.

b. He mentioned that UKRI is exploring an innovative process to repurpose steel from electric arc furnaces for cement production, thereby integrating steel and cement manufacturing.

c. He further stated that Indian industries can leverage their abundant waste resources for biogas production.

2. Mineral Products Association (MPA) - Diana Casey, Executive Director

a. Diana stated that the Mineral Products Association (MPA) is the UK's trade association for the aggregates, asphalt, cement, concrete, dimension stone, lime, mortar, and silica sand industries and represents 100% of the cement production in the UK.

b. She added that emissions from the UK's concrete and cement industry were reduced by 53% in 2018 compared to 1990 levels, surpassing national averages.

c. She highlighted that MPA has successfully operated a kiln burner using a net carbon-zero fuel mixture, with no deterioration in clinker quality and without significant changes in exhaust gas volumes or fuel consumption.

d. She explained the world's largest global carbon capture project undertaken by MPA to decarbonise 40% of cement and lime emissions. The project has the capacity to capture 3 million tonnes of CO_2.

3. Coomtech Clean Technologies - Miri Zlatnar, Sales Director

a. Miri informed that Coomtech is engaged in the development of low-emission technologies for the bulk-solids drying sector and has patented a drying process with low energy requirements.

b. She cited an energy-efficient drying technology called 'Kinetic Drying' developed by Coomtech, which reduces energy consumption and emissions by 75% compared to traditional methods. This technology has the capacity to dry 12 tonnes of material per hour per module.

c. She explained that in the Kinetic Drying process, material is fed into the kinetic dryer system. Controlled turbulent airflow is then injected into the system to remove moisture from the material particles. The extracted moisture is carried away as humidity and diverted through a cyclone at the end of the process.

d. She added that Coomtech has partnered with multiple UK companies for the implementation of its innovative kinetic drying process and has successfully demonstrated its application in drying limestone, sand, concrete, and lignite.

4. CINAR Limited - Tahir Abbas, Director

a. Tahir informed that CINAR is engaged in delivering low CAPEX, affordable, and customisable solutions to reduce emissions across industries. These solutions have been successfully applied to over 400 cement plants.

b. He introduced two in-house techniques developed by CINAR: (i) Computational Fluid Dynamics (CFD) and (ii) MI-CFD. He added that these techniques can be adopted by power plant boilers, incinerators, stationary/aero gas turbines, and cement & lime plants to address pyro-processing and combustion emission-related issues.

c. He highlighted various benefits of MI-CFD technology, such as low cost of implementation, minimal capital expenditure, and quick deployment (within 10-12 weeks).

d. Tahir mentioned that CINAR is conducting a hydrogen simulation to assess the amount of heat generated and coal saved during the hydrogen firing process.

5. British International Investment (BII) - Sami Khan, Director (UK Corporates & Institutions)

a. Sami apprised delegates about British International Investment (BII), specifying that BII is the UK's Development Finance Institution with over 500 investee partners in South Asia. He added that BII is fully owned by the Foreign, Commonwealth & Development Office (FCDO) and has a strong presence in India with 40 team members working across the country.

b. BII is actively investing across numerous sectors, including on-grid renewable energy, energy storage, energy access (mini-grids and solar home systems), transmission & distribution, ports, and logistics.

c. He informed that BII has committed over £94 million in loans to clean energy and resource efficiency companies located in Africa, South/Southeast Asia, and the Caribbean.

d. Sami stated that BII has an investment portfolio of £2.4 billion in India and looks forward to providing low-cost investments to fund renewable energy and energy efficiency projects to support India's energy transition journey.

6. Edina - Adam Bloom, CEO and Hugh Richmond, Strategic Advisor

a. Adam and Hugh informed that Edina offers on-site generation and energy storage solutions to companies, aiming to reduce energy costs and carbon emissions while enhancing energy resilience and asset flexibility.

b. Adam highlighted the specifications of a battery energy storage solution developed by Edina and apprised delegates about a 10 MW, one-hour duration battery energy storage solution deployed in the UK.

c. Sharing a brief overview of various Combined Heat and Power (CHP) projects implemented by Edina in the UK and India, Adam emphasised the critical role of CHP technology in the global transition towards Net Zero.

7. Imperial College, London - Michel Alexandre, Associate Professor

a. Michel highlighted the need for significant investments in decarbonisation technologies to address challenges related to climate change, geopolitical conflicts, and energy transition.

b. He emphasised the importance of flexibility in design to provide a new paradigm for tackling these challenges and informed that Imperial College has developed a design framework to incorporate flexibility in large-scale investment projects.

c. He informed that Jaguar Land Rover adopted Imperial College's flexibility approach for its decarbonisation strategy. This approach resulted in an increase of over 50% in the probability of achieving emissions targets compared to traditional methods.

Summary of the presentations by respective organisations are provided at Annexure - 4.

Key takeaways

- The aluminium and cement industries in India can serve as test beds for innovative energy efficiency and decarbonisation technologies being developed in the UK.
- BII has an investment portfolio of £2.4 billion in India and is looking forward to offering low-cost investments to fund renewable energy and energy efficiency projects to support India's energy transition journey.
- MPA has successfully operated a kiln burner using a net carbon-zero fuel mixture, with no deterioration in clinker quality and without significant changes in exhaust gas volumes or fuel consumption.
- Coomtech's 'Kinetic Drying' technology reduces energy consumption and carbon emissions by up to 75% compared to traditional methods. This technology has the capacity to dry 12 tonnes of material per hour per module.
- CINAR has developed in-house models like CFD and MI-CFD for power plant boilers, incinerators, stationary/aero gas turbines, and cement and lime plants. The database built over thirty years of service is being used to conduct a hydrogen simulation exercise to assess the amount of heat generated and coal saved during the hydrogen firing process for burners.

3 DAY 2 SITE VISITS TO IMPERIAL COLLEGE LONDON & CRANFIELD UNIVERSITY

The business delegation visited Imperial College London and Cranfield University on 21st May 2024 to gain insights into the energy efficiency and decarbonisation initiatives being implemented by these institutes.

3.1 Visit to Imperial College London at South Kensington

The site visit to Imperial College London commenced with an introductory presentation by Imperial College London. This was followed by a tour of the Carbon Capture and Storage (CCS) facility and the Industrial Decarbonisation Lab. Subsequently, representatives from Imperial College London highlighted the decarbonisation research initiatives at the college and hosted a Question & Answer (Q&A) session with the delegates.

3.1.1 Introductory presentation by Imperial College London

Maria Sokolikova, Manager of the Energy Futures Lab at Imperial College London, welcomed the delegates and provided an overview of Imperial College London and the Energy Futures Lab. She mentioned that the Energy Futures Lab is a global energy institute focused on developing sustainable fuels such as hydrogen and biofuels, as well as recovering rare earth materials from batteries. The lab's strategy pivots on three pillars: Net Zero, Sustainability, and Digitalisation, which encompass the following six broad and interconnected research themes:

1. Sustainable Power
2. Sustainable Fuels
3. Energy Infrastructure
4. Low Carbon Cities & Transport
5. Policy & Innovation
6. Materials for Energy




3.1.2 CCS facility and industrial decarbonisation tour

CCS facility

Professor Colin Hale, Senior Teaching Fellow in the Department of Chemical Engineering at Imperial College London, guided the delegates during the CCS facility visit. He stated that the CCS research lab was commissioned in 2012 in collaboration with ABB and specified the primary functions of the lab, such as training, research, and collaboration with UK organisations for the testing and demonstration of CCS technologies.

He informed the delegates that the lab includes a four-story, state-of-the-art carbon capture pilot plant with an annual capacity of capturing 500 tonnes of CO_2. The pilot plant operates on a closed-loop system capable of capturing 99% of CO_2 from flue gases. The plant uses over 250 process instruments to provide real-time information on flow, temperature, pressure, and CO_2 levels to the control room.

Professor Hale explained that CO_2 is captured by reacting carbon dioxide in flue gas with an alkali metal carbonate to form a carbonate salt. The captured CO_2 is then stored using available

minerals or industrial waste containing calcium, magnesium, or iron in non-carbonate forms. He also described the working of the CCS facility as follows:

- A gas mixture saturated with CO_2 is passed through a solution of monoethanolamine (MEA).
- The MEA solution absorbs CO_2 from the gas mixture, leaving behind a purified gas stream suitable for release into the atmosphere.
- The solution is then further processed to separate and store the CO_2.




Industrial Decarbonisation Lab

Professor Paul Fennell, Professor in Clean Energy in the Department of Chemical Engineering at Imperial College London, showcased the industrial decarbonisation lab to the delegates. He informed them that the lab has deployed calcium looping technology, wherein calcium oxide from limestone reversibly reacts with CO_2 in the flue gas to produce a pure stream of CO_2. He further highlighted that this technology also enables the production of cement clinker in a fluidised bed reactor.

Professor Fennell pointed out that Imperial College's research on improving clinker efficiency and enhancing waste recovery from ash has demonstrated significant benefits by converting cement industry waste into valuable primary chemicals for potential future applications.

3.1.3 Decarbonisation initiatives and Q&A

This session covered the industrial decarbonisation initiatives implemented by Imperial College London, followed by a Q&A session moderated by Professor Fennell.

He deliberated on the key issue of utilising CO_2 captured using carbon capture technology and discussed its applications across industries, such as in the production of methanol and other chemicals. He also mentioned that Imperial College has partnered with Tata Chemicals to explore the production of chemicals derived from CO_2. He asserted that transitioning from coal to biomass in cement plants cannot eliminate carbon emissions, and hence alternative solutions may need to be explored.

The session ended with engaging discussions between Professor Fennell and the delegates. Some of the questions raised included ways to explore collaboration opportunities between Imperial College and Indian industries, and the feasibility of Indian industries offering a testing ground for the demonstration of innovative technologies developed by Imperial College. During the discussion, it was suggested that the Cement Manufacturers' Association (CMA) may support compiling the challenges faced by the Indian cement industry and develop a joint proposal with Imperial College London to explore funding opportunities for research and the implementation of a low-carbon technology pilot project in India.

Key takeaways

- Utilisation of captured CO_2 across other industries is critical to promote adoption of CCS technology.
- CMA can act as focal point to develop a joint proposal with the Imperial College London to explore opportunities for conducting research and implementing low-carbon technology pilot projects in India.

3.2 Visit to Cranfield University at Bedfordshire

Visit to the Cranfield University started with a presentation on key research activities and new projects, followed by a lab tour.

3.2.1 Introductory presentation by Cranfield University

Professor Mark Jolly, Professor and Director of Manufacturing at Cranfield University, and Dr. Lampros Litos, Lecturer in Sustainable Manufacturing Operations at the Sustainable Manufacturing Systems Centre (SMSC), commenced the presentation by introducing the research initiatives undertaken by Cranfield University in energy efficiency and decarbonisation across the domains of aerospace, energy and power, manufacturing and materials, and transport. Professor Jolly informed the delegates that the university has partnered with Vellore Institute of Technology (VIT) and Hindustan Aeronautics Ltd (HAL) in aerospace technology.

He apprised the delegates about the Transforming Foundation Industries Research and Innovation Hub (TransFIRe), a consortium of 12 institutions and 80 organisations formed to develop innovative solutions for reducing energy and resource use across Foundation Industries (FIs) - cement, metals, ceramics, glass, paper, and chemicals. This initiative has received £4.7 million in funding from UKRI. He added that Cranfield University, as an academic partner of TransFIRe, provides research support to discover new methods for minimising waste and energy consumption in FIs.

He highlighted that the Sustainable Manufacturing Systems Centre (SMSC) has been established by the university with the aim of decarbonising industrial manufacturing processes. The research centre is focused on developing new manufacturing processes and products through advanced modelling and simulation techniques.

He explained a university-conducted study that benchmarks energy utilisation and CO_2 emissions across FIs. The study compares the energy and CO_2 intensity data of six FIs in the UK against global industries. The study findings highlighted the need for an accurate and reliable method to benchmark energy usage in manufacturing processes. It was further highlighted that the UK's paper industry has a 43% lower carbon footprint and uses 38% less energy than the global paper industry, with the potential to further reduce emissions and energy consumption by 50% through the adoption of best practices.

3.2.2 Lab tour

Professor Supriyo Ganguly, Professor in Welding and Additive Materials Science at the Welding and Additive Manufacturing Centre at Cranfield University, accompanied the delegates to the

lab to showcase the decarbonisation technologies and low-carbon products developed by the university.

He emphasised that Cranfield University is spearheading the research and development of the first major hydrogen technology hub to demonstrate the potential of using hydrogen as a net-zero aviation fuel under the £69 million research programme - Cranfield Hydrogen Integration Incubator (CH2i). Additionally, it was mentioned that Cranfield University can provide technical inputs to the National Institute of Solar Energy (NISE) to establish a centre of excellence on safety for hydrogen in India.

Key takeaways

- New manufacturing processes developed through advanced modelling techniques, coupled with waste materials utilisation techniques, present a significant opportunity to decarbonise industrial manufacturing.
- Hydrogen can be used as a net-zero fuel across several industries, including energy, cement, steel, aluminium, and aviation.
- The National Institute of Solar Energy (NISE) in India is planning to set up a centre of excellence on safety for hydrogen, for which significant technical inputs can be provided by Cranfield University.

4 DAY 3 SITE VISITS TO IMPERIAL COLLEGE LONDON & CRANFIELD UNIVERSITY

The Indian delegates visited Novelis Aluminium Latchford recycling plant situated in Warrington on 22nd May 2024 to gain insights into low-carbon technologies/ initiatives implemented by the aluminium recycling facility.

Site visit commenced with an introductory presentation on Novelis Aluminium recycling facility and HyNet (industrial decarbonisation project), followed by a tour to Latchford aluminium recycling facility.

4.1 Introductory presentation on Novelis Aluminium recycling plant

Andy Doran, Senior Manager, Government Affairs and Recycling Development, Novelis Europe and Allan Sweeney, Plant Manager, Novelis Latchford highlighted that Novelis is the world's largest aluminium recycler. They informed that Novelis' Latchford plant in Warrington is one of Europe's largest aluminium recycling facilities with an annual recycling capacity of 195,000 tonnes. The Latchford plant has Europe's largest closed-loop recycling operations for automotive aluminium rolled products. Allan highlighted several benefits of a closed-loop recycling system for automotives such as lower recycling and transportation costs, minimum environmental impact and preserved aluminium alloy.

Andy specified that Novelis intends to become carbon neutral by 2050 and reduce its CO_2 footprint by 30% by 2026. To achieve these targets, Novelis has developed its decarbonisation strategy to gradually reduce its Scope - 1, 2 and 3 emissions through increase in recycling capabilities and capacities, decarbonisation of melting process and by maximising circularity & closed-loop recycling systems.

Subsequently, he highlighted the following outcomes achieved by Novelis through adoption of energy efficiency and decarbonisation measures[3]:

- 31% reduction in greenhouse gas emissions
- 26% reduction in water intensity
- 40% reduction in non-dross waste to landfill
- 25% reduction in energy intensity

The session also witnessed participation from Adam Baddeley, CEO at Grenian Hydrogen. He spoke about HyNet, the world's leading industrial decarbonisation project and informed that HyNet includes the following infrastructure establishments:

- A low carbon hydrogen production facility.
- Facilities to capture CO_2 emissions.
- An underground pipeline network to transport CO_2 for permanent storage.
- An underground pipeline network to transport hydrogen from production to storage and use.

He mentioned the 'Industrial Fuel Switching' programme, which is being implemented under the HyNet initiative. The phase 1 of the programme demonstrated various fuel switching measures including: (a) Unilever's low carbon hydrogen trial at Port Sunlight facility, (b) Essar's CHP hydrogen trial and Front-End Engineering Design (FEED) at Stanlow refinery, (c) NSG group biofuel trial at St Helens.

3 Outcomes achieved in FY 2020 as compared to baseline averages of Fiscal Years 2007-09

Key takeaways

- A closed-loop recycling system preserves the value of the alloy, reduces recycling & transportation costs and minimises environmental impact.
- Decarbonisation of aluminium scrap melting process, improvement in recycling capabilities and increase in circularity are some of the important levers to reduce Scope - 1, 2 and 3 emissions.
- Industrial fuel switching has significant potential to reduce emissions across energy systems, recycling furnaces and manufacturing facilities.

4.2 Recycling plant tour

Andy Doran accompanied delegates to the Latchford plant and mentioned that aluminium recycling requires only 5% of the energy and emits 5% of CO_2, as compared to producing primary aluminium.

He informed that Novelis joined HyNet in 2017 to conduct technical feasibility studies on the use of hydrogen as a direct replacement for natural gas. He apprised delegates about the £4.6 million funding received by Novelis from Department for Energy Security & Net Zero (DESNZ), UK Government for hydrogen burning trials under a £1 billion Net Zero Innovation Portfolio (NZIP).

He highlighted that the Novelis Latchford plant is planning to conduct hydrogen burning trials for one of its recycling furnaces in October 2024 in collaboration with Progressive Energy, an independent UK energy company. The trial includes replacement of furnace lining material to use hydrogen as a fuel and entails installation of new burners and regenerators which can operate with both hydrogen and blended hydrogen/gas input.

He asserted that replacing natural gas with hydrogen to feed the aluminium remelting furnace could reduce CO_2 equivalent emissions by up to 90% compared to natural gas and stated that these trials will provide valuable insights for cement and aluminium sectors. The Latchford plant has also signed an agreement with Vertex Hydrogen to meet 100% of its natural gas demand. The delivery of low-carbon hydrogen to the plant will commence from 2028.

He affirmed that Novelis' global research and development teams are exploring alternative fuel sources such as plasma, electricity, and biomass for their manufacturing operations.

Key takeaways

- Aluminium recycling requires only 5% of the energy and emits 5% of CO_2 compared to producing primary aluminium.
- Use of hydrogen in aluminium recycling furnaces can reduce CO_2 equivalent emissions by up to 90%.
- Emerging alternative fuel sources like hydrogen, plasma, electricity, biomass will serve as a catalyst for decarbonisation of recycling furnaces.

5 DAY 4 B2B MEETINGS

B2B meetings were organised between Indian delegates and 7 UK technology providers/ organisations on Day-4 of the business trip (23rd May 2024). The UK Representatives included officials from CINAR, Edina, Carbon Upcycling Technologies, E4 Structures, Energy Systems Catapult, ALTEK and Nanomox. The interactions during these discussions focused on strengthening collaboration between Indian industries and UK organisations in the areas of recycling, low-carbon technologies and multi-fuel combustion techniques. The agenda for the B2B meetings is provided below:

S No	Time (BST)	Broad Coverage
23rd May 2024, Thursday		
1.	10:00 - 12:30 hours	• **Session 1:** One-to-One B2B meetings between Indian delegation and below UK organisations.
2.		o CINAR (Sami Khan, Director)
3.		o Edina (Adam Bloom, CEO; Gary Collins, Battery Storage Specialist and Mark Hayward, Applications Manager)
4.		o Carbon Upcycling Technologies (Aaron Lucid, Development & Partnerships Manager)
5.		o E4 Structures (John Cloughley, Director)
6.	13:00 - 15:00 hours	• **Session 2:** One-to-One B2B meetings between Indian delegation and below UK organisations.
7.		o Energy Systems Catapult (ESC) (Aakriti Arora, India Country Manager)
8.		o ALTEK (Simon Laycock, Area Sales Manager)
9.		o Nanomox (Francisco Malaret, CEO)

5.1 B2B Meetings with CINAR, Edina, Carbon Upcycling Technologies & E4 Structures

Session 1 of B2B meetings witnessed the participation of Indian delegates and 4 organisations from UK viz. CINAR, Edina, Carbon Upcycling Technologies, and E4 Structures.

1. **CINAR - Sami Khan, Director**

    a. CINAR discussed the multi-fuel combustion and calcination models they develop and specified that these can be tailored to meet specific requirements of the Indian cement plants.
    b. CINAR can also conduct training sessions and provide technical support to Indian companies for capacity building on its in-house modelling techniques.
    c. Delegates from Indian industry mentioned that cement plants in India face unique challenges owing to different operational structures and limestone mineral composition. Further, it was mentioned that the end-product of firing hydrogen in kiln is water which may react with burner and limestone, thereby impacting the product quality.
    d. Indian delegates asked CINAR to share additional information on modelling tools and use cases on successful implementation of its techniques across the cement industry.
    e. Prism Johnson Limited expressed interest in implementation of CINAR's technology for one of its cement kilns. The company is already working with Indian Institute of Technology (Banaras Hindu University) Varanasi (IIT-BHU) for implementation of pilot project on firing kiln using hydrogen as blended fuel.

2. **Edina - Adam Bloom, CEO; Gary Collins, Battery Storage Specialist and Mark Hayward, Applications Manager**

    a. Representatives from Edina laid out the company's plan to conduct efficiency pilots for bespoke battery storage systems to cater to the needs of Indian companies connected to the grid.
    b. They presented comprehensive cost estimates for battery storage systems and informed that Edina is open to explore partnership opportunities with Indian battery suppliers.
    c. Tentative cost of installing a battery energy storage solution is £ 250 per kilowatt, which includes expenses for battery, inverter and control system and installation charges.
    d. Edina officials informed that they may assist the Indian companies in conducting cost benefit assessment of battery energy storage system and facilitate Battery Energy Storage System (BESS) deployment through energy service company (ESCO).
    e. Delegates from Indian cement manufacturer suggested Edina to collaborate with EXIDE Industries to jointly offer BESS solutions for energy intensive industries in India.

3. **Carbon Upcycling Technologies - Aaron Lucid, Development & Partnerships Manager**

    a. Representative from Carbon Upcycling Technologies apprised delegates about their patented technology, which effectively sequesters CO_2 emissions to create enhanced industrial byproducts. The technology is particularly focused on using fly ash from coal production.

b. Additionally, the representative outlined Carbon Upcycling's global expansion plans and ongoing projects aimed at upcycling waste into valuable products.
c. He highlighted that a CCUS facility needs to have capacity to capture at least 400 tonnes of CO_2 per day. The capital expenditure for setting up such facility ranges between £10 to £20 million, depending upon the type of by-products.
d. During discussion between Carbon Upcycling Technologies and Hindalco Industries, it was decided that Hindalco Industries would provide the chemical composition of red mud, a by-product of Alumina production, to Carbon Upcycling Technologies to assess the feasibility of transforming red mud into a valuable product.
e. Indian delegates from cement industry suggested that Carbon Upcycling can explore ways to utilise and detoxify Spent Pot Lining (SPL), a hazardous waste generated during aluminium production.

4. E4 Structures - John Cloughley, Director

a. Official from E4 Structures informed that the company transforms waste into lightweight raw materials with fire-resistant properties by adjusting porosity of their composite materials.
b. He elaborated about a partnership between E4 Structures and Nanomox to identify ideal sources of new materials for waste to energy companies and remove contaminants from waste.
c. Apart from being a technology incubator, E4 Structures is also looking to scale up material production and secure investment for material development and deployment.
d. Prism Johnson Limited expressed interest in partnering with E4 Structures for a study on alternative solutions for building construction material.
e. Indian delegates highlighted that waste materials like Refuse Derived Fuel (RDF) and Municipal Solid Waste (MSW) are either used as fuel or end up in landfills. They suggested E4 Structures to establish an R&D centre in India to convert / utilise RDF and MSW into useful construction material.

Key takeaways

- Indian delegates requested additional information from CINAR regarding its modelling tools and successful use cases in the cement industry.
- Prism Johnson Limited expressed interest in implementation of CINAR's technology for one of its cement kilns.
- Edina offered assistance to Indian companies in conducting cost benefit assessment of battery energy storage system (BESS) and facilitating BESS deployment through ESCOs.
- Indian cement industry delegates recommended Carbon Upcycling Technologies to explore ways to utilise and detoxify spent pot lining, a hazardous waste from aluminium production.
- Prism Johnson Limited indicated interest in partnering with E4 Structures for a study on alternative solutions for building construction material.


Our technology
Our patented technology sequesters CO_2 and upcycles industrial byproducts into enhanced material to replace up to 50% clinker in cement and reduce cement emissions by up to 50%
Industrial byproducts
Carbon Upcycling
at the cement plant
Low-Carbon Cement
40%
reduced
up to 50%
up to 50%

5.2 B2B Meetings with Energy Systems Catapult, ALTEK & Nanomox

During Session 2 of the B2B meetings, 3 UK companies/technology providers - Energy Systems Catapult, ALTEK and Nanomox interacted with the Indian delegates.

1. **Energy Systems Catapult (ESC) - Aakriti Arora, India Country Manager**
    a. Representative from ESC explained that ESC serves as a platform for government funding in pilot projects related to decarbonisation and energy storage solutions. She also highlighted ESC's role in scaling up decarbonisation solutions for the cement sector.
    b. ESC supports projects in the areas of energy storage, green hydrogen and clean energy. Recent ESC projects in India include sodium-ion batteries in Delhi for LINA energy plants and cloud-based analytical solutions to assess battery life for Faraday Battery.
    c. Delegates from cement and aluminium sectors expressed interest in deployment of innovative IEED technologies such as large-scale hydrogen, oxy-fuel, CCS, waste to energy, battery energy storage, cloud based analytical solutions etc.
    d. Indian delegates have requested additional information from ESC regarding the UK Government's funding mechanism for implementing RE-related projects across cement and aluminium sectors in India.

2. **ALTEK - Simon Laycock, Area Sales Manager**

    a. ALTEK official provided insights on the technology solutions offered by ALTEK such as air-cooled Electromagnetic Furnace Stirring (EMS) to eliminate water usage, retrofit of furnaces with electromagnetic stirrers, on-site rotary furnace dross processing, etc.
    b. He added that ALTEK is exploring the possibility to utilise non-volatile and non-reactive dross waste from cement production by modifying the existing waste and aluminium recovery technologies.
    c. ALTEK is open to share detailed information on their technology solutions including total dross management, electromagnetic stirrer, zero waste solutions, etc. with Indian aluminium industry delegates to explore collaboration opportunities.

3. **Nanomox - Francisco Malaret, CEO**

    a. Nanomox CEO explained a cost-effective wet chemical process developed by Nanomox to produce advanced materials such as Zinc Oxide (ZnO), which has a potential to save ~97% of energy as compared to traditional methods.
    b. He highlighted that Nanomox has partnered with E4 Structures to procure new materials, utilise waste materials and ensure adherence with environmental standards by efficiently repurposing waste materials.
    c. Delegates from cement industry indicated interest in utilisation of ZnO for manufacturing of tiles & development of anti-crack cement using product mix offered by Nanomox.

Key takeaways

- Indian delegates from the cement and aluminium sectors are keen on deployment of innovative IEED technologies such as large-scale hydrogen, oxy-fuel, CCS, waste to energy, battery energy storage, cloud based analytical solutions etc.
- ALTEK is open to share detailed information about their technology solutions, including total dross management, electromagnetic stirrer, zero waste solutions, etc. with Indian aluminium industry delegates to explore collaboration opportunities.
- Representatives from Indian cement industry have expressed interest in utilising Zinc Oxide for tile manufacturing and developing anti-crack cement using the product mix offered by Nanomox.

6 ANNEXURE 1
AGENDA OF THE BUSINESS TRIP

S.No	Time (BST)	Broad Coverage
		20th May 2024, Monday
1.	13:00 - 17:30 hours **Location-** 15 Canada Square, Canary Wharf, London, E14 5GL	**Location:** KPMG UK Office, Canary Wharf **Purpose of Visit:** o Roundtable discussion with UK industry associations, research institutions and companies. o The objective of the roundtable discussion is to deliberate on the best practices/ current state of Industrial Energy Efficiency (IEE) and decarbonisation technology solutions in the UK and strengthening of UK-India collaboration in the areas of low carbon technologies, innovations and investments. *(Detailed agenda for Roundtable discussion is provided in Section 2)*
		21st May 2024, Tuesday
2.	10:00 - 14:00 hours **Location**- Exhibition Rd, South Kensington Campus, London SW7 2BX	***Facility Name:*** *Imperial College, London at South Kensington* ***Purpose of the visit:*** o Gain insights into the Carbon Capture and Storage (CCS) research program of Imperial College. o Understand operation of 4 story CCS facility deployed by Imperial College at South Kensington. *Imperial College, London has the UK's largest carbon capture and storage (CCS) research program. The college has installed a refurbished pilot CO_2 capture plant at South Kensington, London.* *The college host Qatar Carbonates and Carbon Storage Research Centre, one of the largest industry funded CCS programmes ($70M over 10 years) aimed at improving the understanding of middle east carbonate reservoir complexes.*
3.	14:00 - 16:00 hours (**Travel Time- ~**2 hrs)	• Travel from South Kensington, London to Cranfield University, Bedfordshire
4.	16:00 - 18:00 hours **Location**- College Rd, Wharley End, Bedford MK43 0AL	***Facility Name:*** *Cranfield University at Bedfordshire* ***Purpose of the visit:*** o Gain insights into research and development projects undertaken by Cranfield University on energy and resource efficiency practices in manufacturing. o Understand innovative solutions which can be used to reduce energy and resource use within the foundation industries- cement, glass, ceramics, paper, metals and bulk chemicals. *Cranfield University has established Transforming Foundation Industries Research and Innovation Hub (TransFIRe) under a UKRI funded programme focused on developing innovative solutions to reduce energy and resource use across the Foundation Industries (FIs)- cement, metals, ceramics, glass, paper, among others.* *TransFIRe is a consortium of 20 investigators from 12 institutions, and project partners from more than 80 organisations with expertise in areas such as energy mapping, life cycle and sustainability, industrial symbiosis across FI sectors.*
		22nd May 2024, Wednesday
5.	08:00 - 12:30 hours (**Travel Time- ~**4.5 hrs)	• Travel to Novelis Latchford Aluminium recycling facility at Latchford, Warrington, Cheshire

S.No	Time (BST)	Broad Coverage
6.	12:30 - 16:15 hours **Location**- Latchford Locks Works, Thelwall Ln, Warrington, Cheshire WA4 1NN	***Facility Name:*** *Novelis Latchford Aluminium recycling facility at Latchford, Warrington* ***Purpose of the visit:*** o Gain insights into the trial use of hydrogen in aluminium recycling furnaces. o Understand the impact of hydrogen based Aluminium remelting furnaces in reducing CO_2 emissions. *Novelis Latchford in Warrington is one of the Europe's largest aluminium used beverage cans recycling plants and has the largest closed-loop recycling operation for automotive aluminium rolled products in Europe with an annual recycling capacity of up to 195,000 tonnes. The plant has capacity to recycle every aluminium beverage can sold in the UK*
23rd May 2024, Thursday		
7.	10:00 - 12:30 hours	**Block 1:** One-to-One B2B meetings between Indian delegation and below UK organisations in a speed networking format, with Indian delegation members circulating around each room to meet with different companies
8.		**Carbon Upcycling, London** Carbon Upcycling is a waste and carbon utilisation company. Their technology blends CO_2 with natural materials or industrial wastes from coal plants, steel plants, etc. to develop new materials.
9.		**CINAR, London** CINAR is a specialist consultancy firm engaged in design and delivery of innovative solutions for the cement industry. CINAR has been engaged in solving industrial problems related to pyro-processing and combustion emissions for the last 25 years using its in-house computational fluid dynamics (CFD) simulations.
10.		**E4 Structures** E4 structures specialises in designing and constructing innovative and sustainable building solutions. It has been engaged in delivering low environmental impact materials for construction, underfloor heating, wall panels, etc.
11.		**Edina** Edina specialises in the deployment of on-site power generation and energy storage systems to assist high energy users within the industrial, commercial, and public sectors. It is owned by EnergyPro Assets Limited (EPAL), a joint venture between Energy Efficiency Services Limited (EESL), and EnergyPro Ltd.
12.	13:00 - 15:00 hours	**Block 2:** One-to-One B2B meetings between Indian delegation and below UK organisations in a speed networking format, with Indian delegation members circulating around each room to meet with different companies
13.		**ALTEK** ALTEK is technology-based company with expertise in designing, manufacturing and installation of aluminium dross and scrap processing systems. It supplies capital equipment and products to improve productivity and reduce waste across Aluminium industry.
14.		**Energy Systems Catapult** Energy Systems Catapult is an independent research and technology organisation focused on helping industries, businesses, local authorities to transition towards Net-Zero. Energy Systems Catapult is also part of a network of nine world-leading technology and innovation centres, established by Innovate UK.
15.		**Nanomox** Nanomox is engaged in the development of sustainable and cost-effective advanced materials and thin films, such as metal oxide particles, with sizes ranging from nano to macro, for widespread applications across various industries such as iron & steel, cement, etc.

7 ANNEXURE 2
COMPOSITION OF DELEGATION

The delegation includes representatives from the Ministry of Power, Bureau of Energy Efficiency (BEE), FCDO and cement and aluminium industries. Total - 17 delegates (including FCDO, KPMG and Idam).

Ministry of Power (MoP)		
1		**Dhiraj Kumar Srivastava** Chief Engineer, Ministry of Power
Bureau of Energy Efficiency (BEE)		
2		**Sunil Khandare** Director, Bureau of Energy Efficiency
3		**Vivek Negi** Joint Director, Bureau of Energy Efficiency
Foreign, Commonwealth and Development Office (FCDO)		
4		**Archana Chauhan** Head, Energy Sector Reform British High Commission
Industry Delegates from Cement and Aluminium Industry		
5		**Anji Reddy** Senior Vice President, Sagar Cements Limited
6		**Kapilavai Narayana Rao** Corporate Head (EHS and Sustainability) My Home Industries Pvt. Ltd.
7.		**Man Mohan Rathi** Joint President (Power), Shree Cement Limited

8.		**Manish Singh** President & Plant Head, Prism Johnson Limited
9.		**Om Prakash** Vice President, Prism Johnson Limited
10.		**Rajesh Sankar P** President, Ultratech Cement Limited, Rawan Cement Works, Chhattisgarh
11.		**Sachin Kumar Gupta** Deputy Business Unit Head, Power Supply & Common Services, Vedanta Aluminium
12.		**Shubho Chakravarthy** Assistant Manager, Cement Manufacturers Association
13.		**Subhas Nesargi** HOD-Electrical & Instrumentation, Hindalco Belagavi (Karnataka)
14.		**Vinay Kapil** Executive Director, Dalmia Cement (Bharat) Limited
	ASPIRE Team	
15.		**Vikas Gaba** Programme Director, ASPIRE programme Partner & National Head, Power & Utilities, KPMG in India
16.		**Ramit Malhotra** Smart Power Lead, ASPIRE programme Director, KPMG in India
17.		**Rajiv Kumar Shukla** Executive Director, Distributed Renewable Energy (DRE), Idam Infrastructure Advisory Private Limited

8 ANNEXURE 3
LIST OF ATTENDEES

S. No.	Name	Designation
	Ministry of Power	
1	Mr. Dhiraj Kumar Srivastava	Chief Engineer
	Bureau of Energy Efficiency	
2	Mr. Sunil Khandare	Director
3	Mr. Vivek Negi	Joint Director
	Foreign, Commonwealth and Development Office (FCDO)	
4	Ms. Archana Chauhan	Head, Energy Sector Reform, British High Commission
5	Ms. Yasmin Visanji	Head of Global Goods, India and Indian Ocean Directorate
	Industry Delegates from Cement and Aluminium Industry	
6	Mr. Anji Reddy	Senior Vice President, Sagar Cements Limited
7	Mr. Kapilavai Narayana Rao	Corporate Head (EHS & Sustainability), My Home Industries Pvt. Ltd.
8	Mr. Man Mohan Rathi	Joint President (Power), Shree Cement Limited
9	Mr. Manish Singh	President & Plant Head, Prism Johnson Limited
10	Mr. Om Prakash	Vice President, Prism Johnson Limited
11	Mr. Rajesh Sankar P	President, UltraTech Cement Limited (Rawan Cement Works)
12	Mr. Sachin Gupta	Deputy Business Head and Energy Manager, Vedanta Aluminium
13	Mr. Shubho Chakravarthy	Assistant Manager, Cement Manufacturers Association
14	Mr. Subhas Nesargi	HOD - Electrical & Instrumentation, Hindalco Industries Belagavi
15	Mr. Vinay Kapil	Executive Director, Dalmia Cement (Bharat) Limited
	Representatives from UK organisations	
16	Mr. Bruce Adderley	Challenge Director, UK Research and Innovation (UKRI)
17	Ms. Diana Casey	Executive Director, Mineral Products Association (MPA)
18	Ms. Miri Zlatnar	Sales Director, Coomtech Clean Technologies
19	Mr. Tahir Abbas	Director, CINAR
20	Mr. Sami Khan	Director, UK Corporates & Institutions, British International Investment
21	Dr Michel Alexandre	Associate Professor at the Dyson School of Design Engineering, Imperial College London
22	Mr. Adam Bloom	CEO, Edina
23	Mr. Hugh Richmond	Strategic Advisor, Edina
24	Mr. Gary Collins	Battery Storage Specialist, Edina

S. No.	Name	Designation
25	Mr. Mark Hayward	Applications Manager, Edina
26	Mr. John Cloughley	Director, E4 Structures
27	Mr. Aaron Lucid	Development and Partnerships Manager, Carbon Upcycling Technologies
28	Mr. Simon Laycock	Area Sales Manager, ALTEK
29	Mr. Francisco Malaret	CEO, Nanomox
30	Ms. Aakriti Arora	India Country Manager, Energy Systems Catapult
Representatives from field visit to Imperial College London		
31	Dr Maria Sokolikova	Research Development Manager, Energy Futures Lab
32	Dr Paul Fennell	Professor in Clean Energy, Department of Chemical Engineering
33	Dr Abigail Ackerman	Royal Academy of Engineering Research Fellow in Sustainable Metallurgy, Department of Materials Engineering
34	Prof. Nigel Brandon	Dean of Faculty of Engineering, Professor of Sustainable Development in Energy
35	Prof. David Dye	Professor of Metallurgy, Department of Materials Engineering
36	Dr Rupert Myers	Senior Lecturer in Sustainable Materials Engineering, Department of Civil and Environmental Engineering
37	Dr Anusha Shimoga Basavaraj	Post-Doctoral Research Associate in 'Engineered UK clays for production of low-carbon cements' project
38	Dr Marcus Yio	Research Fellow, Department of Civil and Environmental Engineering
Representatives from field visit to Cranfield University		
39	Prof. Mark Jolly	Professor and Director of Manufacturing and Materials
40	Dr Lampros Litos	Lecturer in Sustainable Manufacturing Operations, Sustainable Manufacturing Systems Centre
Representatives from field visit to Novelis Aluminium Latchford facility		
41	Mr. Allan Sweeney	Plant Manager, Novelis Latchford
42	Mr. Andy Doran	Senior Manager - Government Affairs and Recycling Development, Novelis Europe
43	Mr. Adam Baddeley	CEO, Grenian Hydrogen
ASPIRE team		
44	Mr. Vikas Gaba	Programme Director, ASPIRE programme Partner & National Head, Power & Utilities, KPMG India
45	Mr. Ramit Malhotra	Smart Power Lead, ASPIRE programme Director, KPMG India
46	Mr. Rajivkumar Shukla	Executive Director, Idam Infrastructure Advisory Private Limited
47	Mr. Tom Williams	Director, KPMG UK
48	Ms. Cathy Chen	Associate Director, KPMG UK
49	Mr. Sol Rosier	Assistant Manager, KPMG UK
50	Mr. Hammond Ozakpolor	Analyst, KPMG UK

9 ANNEXURE 4

SUMMARY OF PRESENTATIONS BY UK ORGANISATIONS

S. No.	Discussion point	Key takeaways
		UK Research and Innovation (UKRI)
1.	About UKRI	• UKRI is a public body under the UK Government that funds research and innovation to drive economic growth, create jobs and high-quality public services.
2.	Use of slag in cement	• To address the issue of declining availability of slag in the UK, UKRI is exploring an innovative process to repurpose steel from electric arc furnaces for cement production, integrating steel and cement manufacturing.
3.	Small Modular Reactors (SMR)	• There is a sizeable demand for SMR technology in power generation owing to low initial cost, enhanced safety measures and the ability to provide reliable and low-carbon energy
4.	Leverage waste for biogas	• Industries in India can leverage their abundant waste resources for biogas production
5.	Investment challenge	• Huge investment is required to scale up sustainable energy technologies.
6.	Wind energy potential in UK	• Availability of solar energy in UK is constrained, however, there is significant potential of utilising wind energy to increase RE penetration
7.	Areas of collaboration	• There is scope for collaboration in decarbonisation between the UK and India across foundation industries such as glass, metal, chemical, paper, ceramic and cement.
		Mineral Products Association (MPA)
1.	About MPA	• MPA is the UK trade association for the aggregates, asphalt, cement, concrete, dimension stone, lime, mortar, and silica sand industries. • MPA represents 100% of the cement production capacity in UK
2.	Emissions from cement industry in UK	• Cement industry contributes to ~1.5% of total UK's emissions. • Energy (both thermal and electrical) accounts for 35% of operating costs of the cement industry. • The UK's concrete and cement industry has reduced emissions by 53% as compared to 1990 levels, surpassing national averages. • MPA is instrumental in driving this progress by stimulating and coordinating sustainability efforts across sectors to maximise impact.
3.	Initiatives to increase energy efficiency & reduce CO_2 emissions in UK	• Various programmes and policy initiatives have been undertaken by UK Government to improve energy efficiency and reduce CO_2 emissions. • Few such initiatives include climate change agreements, energy savings opportunities scheme, energy intensive industries exemption, industrial energy transformation fund etc.

S. No.	Discussion point	Key takeaways
4.	Carbon capture project	• MPA has undertaken the largest global carbon capture project with the objective of decarbonising 40% of cement and lime emissions. • This project has the capacity to capture 3 million tonnes of CO_2 and will be implemented through cross-plant collaboration
5.	Concrete and cement industry roadmap	• MPA developed 'UK Concrete and Cement Industry Roadmap to Beyond Net Zero' highlighting the role of low carbon cement and concrete, fuel switching, and carbon, capture, usage and storage to achieve net zero in UK.
6.	Industrial energy efficiency and accelerator project	• MPA has led the 'Industrial Energy Efficiency and Accelerator Project' to develop multi-component cements comprising of fly ash/ ground granulated blast furnace slag, limestone powder, and Portland cement clinker to replace traditional cement. • These multi-components cements have potential to reduce emissions by over 4 million tonnes of CO_2.
7.	Energy Innovation Programme	• Energy Innovation Programme, funded by the UK Government, has been allocated £3.2 million to demonstrate the following zero-carbon fuel technologies: o Hydrogen and biomass fuel for the primary burner at Heidelberg Materials Ribblesdale plant. o Plasma (electrification) and biomass for the calciner at Tarmac Tunstead plant.
8.	Net carbon zero fuel mix for Kiln burner	• MPA has successfully demonstrated that the kiln burner can be operated using a net carbon-zero fuel mixture, with no deterioration in clinker quality and without significant changes in exhaust gas volumes or fuel consumption.
9.	Research on calcined clay	• MPA apprised delegates about their ongoing research on calcined clays, with a report expected to be released in October 2024.
10.	Challenges in CCUS adoption	• The high cost of CCU technologies and CO_2 transportation, along with the low carbon price, is hindering the adoption of CCUS by energy-intensive industries in the UK.
	Coomtech Clean Technologies	
1.	About Coomtech	• Coomtech Clean Technologies is engaged in development of low emission technologies for bulk-solids drying sectors. They have patented a low & controllable energy requirement drying process.
2.	Drying market and traditional method	• Raw materials used in industries like chemicals, cement, aggregates, waste, batteries, sand, minerals, pharmaceuticals, food, mining etc. are needing to be dried before use. • Global market for drying is > £ 780 billion. • Outdated thermal drying methods currently in use result in the inefficient drying of millions of tonnes of materials, leading to significant energy waste and the generation of millions of tonnes of CO_2 emissions.

S. No.	Discussion point	Key takeaways
3.	Kinetic Drying Technology	• Coomtech has developed an innovative and energy efficient drying technology known as Kinetic Drying. • Coomtech's patented technology works as follows: o Materials is fed into the kinetic dryer system and subjected to a flow of warm air. o Controlled turbulent airflow is then injected in the system to remove moisture from the material particles. o The extracted moisture is carried away as humidity and diverted through a cyclone at the end of the process. • The technology is used in drying cementitious products and uses up to 75% less energy and emissions compared to traditional methods. • System uses AI technology to adapt in real-time to improve the performance and efficiency of the process.
4.	Application of kinetic drying	• Coomtech has successfully demonstrated the application of kinetic drying technology for drying limestone, sand, concrete, and lignite. • Coomtech is currently working on the drying of recycled batteries.
5.	Hydrogen pilot	• Coomtech is engaged in a pilot project with Kawasaki Industries for producing hydrogen from lignite coal. Lignite is dried using kinetic drying technology to remove 30% of its water content.
6.	Engagement with UK companies	• Coomtech has partnered with multiple UK companies for the kinetic drying process. • The first kinetic drying pilot was conducted for bituminous coal in the UK.
7.	Engagement with Indian companies	• Coomtech has partnerships with JSW and the Aditya Birla Group in India
	CINAR Limited	
1.	About CINAR	• CINAR is engaged in providing technical services to address pyro-processing and combustion emission-related issues for energy-intensive industries using its in-house developed techniques. • It has extensive industrial experience in dealing with burners, combustion efficiency, process optimisation and conversion/ upgrades, and the use of alternative fuels such as AFR, pet coke, and biofuels. • It has worked with numerous industries, including power, iron & steel, cement and lime, glass, and ceramic industries.
2.	CINAR products	• CINAR delivers low CAPEX, affordable, and customisable solutions to reduce emissions for industry. • These solutions have been successfully applied to over 350 kilns and calciners.
3.	In-house models	• CINAR has developed in-house models like CFD and MI-CFD for power plant boilers, incinerators, stationary/aero gas turbines, and cement and lime plants, among others. • The MI-CFD technique encapsulates mineral interaction and multi-fuel combustion models, requires low CAPEX, and has an implementation period of just 10-12 weeks. • CINAR's extensive database, built over thirty years of service, provides the MI-CFD model with comprehensive kinetic and reaction rate data.

S. No.	Discussion point	Key takeaways
4.	Hydrogen simulation	• CINAR is conducting a hydrogen simulation to assess the amount of heat generated and coal saved during the hydrogen firing process.
		British International Investment (BII)
1.	About BII	• British International Investment (BII) is the UK's Development Finance Institution, valued at over £2.1 billion, with 500+ investee partners in South Asia, and operates in five cities in the region. • BII is fully owned by the Foreign, Commonwealth & Development Office (FCDO) and has a strong presence in India with 40 team members working across the country.
2.	Sectors	• BII is actively investing in the following sectors: o On-grid renewable energy and energy storage o Energy access (mini-grids and solar home systems) o Transmission & distribution o Ports and logistics • BII is also focusing on financing emerging sub-sectors like on-grid gas power, emission-free hydrogen, and green transportation.
3.	Capital Investments	• BII provides patient capital and has committed over £94 million in loans to pioneering clean energy and resource efficiency companies located in Africa, South/Southeast Asia, and the Caribbean. • The ticket size for loans ranges from approximately £3.9 million for nascent sub-sectors (i.e., mini grids) to as high as £39 million for mature sub-sectors. • BII has funded numerous businesses involved in the development and operation of multiple power generation facilities such as: o Globeleq - Africa's largest developer, owner, and operator of Independent Power Producers (IPPs) with a diverse portfolio of 2.2 GW in operation o Ayana Renewable Power - Developer, owner, and operator of renewable energy projects in India with 1.3 GW of operational projects • BII has committed £11.8 million in investments to the SUSI Asia Energy Transition Fund (SAETF), which targets investments across the energy transition infrastructure spectrum, including renewable energy, energy efficiency, and energy storage projects.
		Edina
1.	About Edina	• Edina is partly owned by Energy Efficiency Services Limited (EESL), the world's largest energy service company operating under the Ministry of Power, Government of India.
2.	Edina's offerings	• Edina provides distributed energy solutions for hydrogen-enabled MWM gas-fired power plants and standby mission-critical power generation. • It offers on-site generation and energy storage solutions to businesses with the aim of reducing energy costs and carbon emissions, while enhancing energy resilience and asset flexibility. • Edina is engaged in providing a full engineering, procurement, and construction (EPC) solution to meet the strategic requirements of businesses from a single point of delivery.

S. No.	Discussion point	Key takeaways
3.	BESS specifications	• Edina has developed a battery energy storage solution with the following features: o 9000 cycle/high power density o Sophisticated battery management system to ensure battery safety, operation, and performance o Faster and cheaper to install o Liquid-cooled battery system • Implemented a 10 MW, one-hour duration battery energy storage solution in the UK.
4.	MWM gas engines	• Edina highlighted that gas engines manufactured by MWM can operate with a 25% hydrogen blend, providing high efficiency and optimal fuel efficiency. • MWM is currently engaged in a pilot project for 100% pure hydrogen gas engines.
5.	CHP projects	• Edina provided a brief overview of the following Combined Heat and Power (CHP) projects: o 800 kWe Trigeneration plant in India o 4 MW CHP plant in the UK o 20 MW flexible generation project in the UK
	Imperial College, London	
1.	Investment in decarbonisation technologies	• Imperial College emphasised that massive investments will be required in decarbonisation technologies to address challenges related to climate change, geopolitical conflicts, and energy transition. • It was highlighted that there is a need to adopt new tools and methods to support better investment and decision-making.
2.	Flexibility design framework	• The Strategic Engineering Lab at Imperial College is engaged in designing methodologies to improve economic value, sustainability, and resilience in complex engineered systems. • Imperial College has developed a design framework to incorporate flexibility in investment projects. • Flexibility in design provides a new paradigm to tackle the challenges and uncertainties related to climate change, net-zero goals, and energy transition faced by industries.
3.	Decarbonisation strategy for JLR	• Automotive manufacturing is one of the most emissions-intensive industries, encompassing Scope - 1, 2, & 3 emissions. • Existing methods deployed by automotive companies are deterministic and may lead to incorrect planning and decisions. • Imperial College supported Jaguar Land Rover by deploying a simulation approach based on standard net present value analysis and real options modelling based on decision rules. • The simulation approach considered new design solutions for direct air capture and battery, and car component recycling. • The approach also assisted in assessing the probability of achieving emissions targets. • Jaguar Land Rover achieved over 50% economic improvement from a dynamic portfolio of flexible strategies and improved the probability of achieving emissions targets by over 50% compared to the deterministic method.

For more information, please contact:

Archana Chauhan

Head, Energy Sector Reform
British High Commission
archana.chauhan@fcdo.gov.uk

Vikas Gaba

Programme Lead,
ASPIRE programme,
Partner and National Head,
Power & Utilities,
KPMG in India,
vikasgaba@kpmg.com

Ramit Malhotra

Smart Power Lead,
ASPIRE programme
Director, Power and Utilities
KPMG in India
ramitmalhotra@kpmg.com